



Name: _____

Date: _____

Student Exploration: Quadratics in Polynomial Form

Vocabulary: axis of symmetry, parabola, quadratic function, vertex of a parabola

Prior Knowledge Questions (Do these BEFORE using the Gizmo.)

1. Farmer Bob has a small square garden that is x feet by x feet. What is the area of his garden? _____



2. He decides to add 2 feet to one side of the garden and 7 feet to the other side.

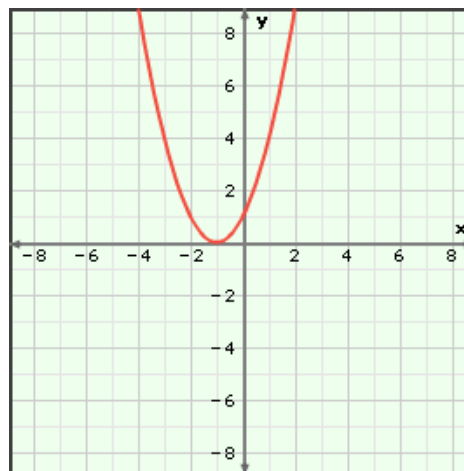
A. What are the lengths of the sides of the new garden? _____

B. What is the area of the new garden? _____

Gizmo Warm-up

In the *Quadratics in Polynomial Form* Gizmo™, you can explore **quadratic functions** of the form $y = ax^2 + bx + c$, with $a \neq 0$. The graph of a quadratic function is a **parabola**.

You can vary the values of a , b , and c by dragging the sliders. To enter a specific value, click on the number in the text field, type in the new value, and hit **Enter**.



1. Vary the value of a .

A. What is true of all parabolas when a is positive?

B. What is true of all parabolas when a is negative? _____

2. Set $a = 0$.

A. How does the graph look when $a = 0$? _____

B. Why do you think the definition of a quadratic function states that $a \neq 0$? _____



Activity A: The function $y = ax^2 + bx + c$	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Be sure Show vertex and intercepts, Show vertex trail, and Show axis of symmetry are turned off. 	$y = ax^2 + bx + c$ $y = x^2$
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1. Consider the function $y = x^2$. (Do not use the Gizmo yet.)

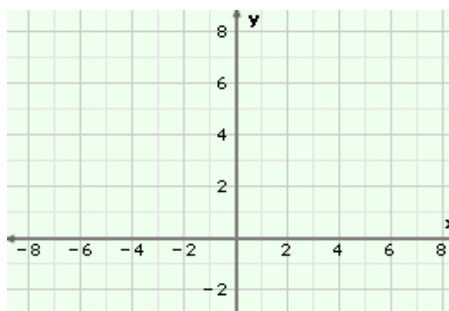
A. Do you think the value of y will ever be negative for this function? _____

Why or why not? _____

B. In the table to the right, fill in the missing y -values, using $y = x^2$.

x	y
-3	
-2	
-1	
0	
1	
2	
3	

C. Plot the points on the grid. Connect them with a smooth curve.



D. In the Gizmo, graph $y = x^2$. Check your answers, on the graph and in the **TABLE**. Fix any mistakes if needed.

E. What is true about the y -values on either side of $x = 0$?

2. With the **CONTROLS** tab chosen in the Gizmo, make sure $y = x^2$ is still graphed.

A. If you double the y -value of every point on this graph, how will the graph change?

B. What equation do you think will describe the graph when the y -values are doubled?

_____ Check your answer in the Gizmo.

C. In the Gizmo, explore the functions $y = 3x^2$ and $y = 0.5x^2$. Compare the graphs to the graph of $y = x^2$. What do you notice? _____

D. Give an example of a quadratic function whose graph is steeper (narrower) than the graph of $y = x^2$ and opens down. _____ Explain. _____

(Activity A continued on next page)



Activity A (continued from previous page)

3. In the Gizmo, graph the function $y = x^2$ again.

A. How do you think adding 2 to every y -value will change the graph? _____

B. What equation do you think describes the graph when 2 is added to every y -value?

_____ Check your answer in the Gizmo.

C. In the Gizmo, vary the value of c . How does the graph change as c increases?

D. How does the graph change as c decreases? _____

E. The **vertex of a parabola** is the minimum or maximum point on a parabola. How do you think the vertex will move as you vary the value of c with the slider?

Check your answer by turning on **Show vertex trail** and dragging the c slider.

F. How far will the graph of $y = -2x^2 + x - 5$ be from the graph of $y = -2x^2 + x - 1$?

_____ Explain. _____

4. Turn off **Show vertex trail** and graph $y = x^2$.

A. Vary the value of b . Describe the path of the vertex as you do so. _____

Check your answer by selecting **Show vertex trail** and dragging the b slider.

B. What happens to the y -intercept as b varies? _____

C. Use the general form of a quadratic function, $y = ax^2 + bx + c$, to explain why varying b does not change the parabola's y -intercept.

D. When is the vertex the same as the y -intercept? _____



Activity B: The intercepts, vertex, and axis of symmetry	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> Turn off Show vertex and intercepts, Show vertex trail, and Show axis of symmetry. 	
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- In the Gizmo, graph the function $y = x^2 - 2x - 3$. Select the **TABLE** tab.
 - How does a table show the x-intercept(s) of a function? _____

 - How does a table show y-intercept(s)? _____
 - What are the intercepts of $y = x^2 - 2x - 3$? x-int: _____ y-int: _____
 - Where does the vertex of a parabola lie, relative to the x-intercepts? _____

 - If you know the x-coordinate of the vertex, how can you find the y-coordinate? _____

 - What is the vertex of $y = x^2 - 2x - 3$? _____ Select the **CONTROLS** tab and turn on **Show vertex and intercepts** to check your answers.
- In the Gizmo, graph $y = -x^2 - 5x$. State the intercepts and vertex.
 x-intercepts: _____ y-intercept: _____ vertex: _____
- Next graph $y = 3x^2 + 6x + 7$. State the intercepts and vertex.
 x-intercepts: _____ y-intercept: _____ vertex: _____
- Look back at the quadratic functions you have graphed. Try to find patterns in your answers.
 - In general, what is the y-intercept of $y = ax^2 + bx + c$? _____
 - What is the x-coordinate of the vertex of $y = ax^2 + bx + c$? (Use a and b .) _____
 - The **axis of symmetry** of a parabola is a line through the vertex, slicing the parabola in half. What is the formula for the axis of symmetry of $y = ax^2 + bx + c$? _____
 Then, in the Gizmo, select **Show axis of symmetry** to check your answers.

(Activity B continued on next page)



Activity B (continued from previous page)

5. Without graphing, state the y -intercept, the axis of symmetry, and the vertex of each one of the quadratic functions below.

A. $y = x^2 + 2x - 3$ y -int: _____ axis of symmetry: _____ vertex: _____

B. $y = 2x^2 + 8x + 3$ y -int: _____ axis of symmetry: _____ vertex: _____

C. $y = -5x^2 + 4x$ y -int: _____ axis of symmetry: _____ vertex: _____

Check your answers by graphing the functions in the Gizmo.

6. Some quadratic functions can be factored. Below are some examples, written in polynomial and factored form. Graph them in the Gizmo, and find each one's x -intercept(s) and vertex.

A. $y = x^2 - 3x + 2$ x -intercept(s): _____ vertex: _____
 $= (x - 1)(x - 2)$

B. $y = 2x^2 + 2x - 12$ x -intercept(s): _____ vertex: _____
 $= 2(x - 2)(x + 3)$

C. $y = x^2 + 2x + 1$ x -intercept(s): _____ vertex: _____
 $= (x + 1)(x + 1)$

D. When a polynomial factors, what do the factors tell you about the graph? _____

E. How can the factors of a quadratic tell you when the vertex of a parabola lies on the x -axis? _____

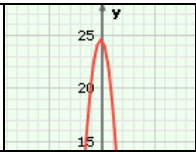
7. Suppose the x -intercepts of a parabola are -1 and 5 .

A. What is the x -coordinate of the vertex of this parabola? _____ How do you know?

B. Write a quadratic function with these x -intercepts. _____

8. Write two different quadratic functions with an axis of symmetry of $x = 2$. Explain how you came up with your answers.



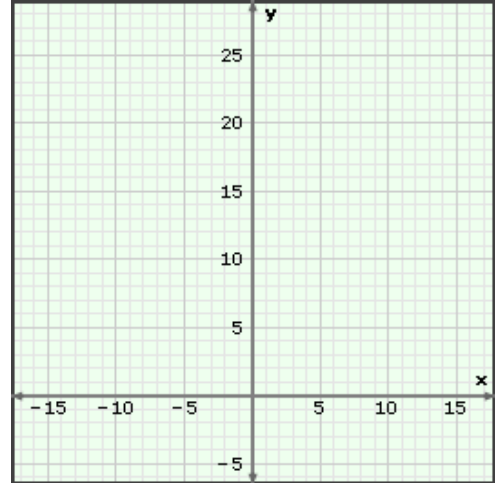
Activity C: Objects in motion	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> • Turn off Show vertex and intercepts, Show vertex trail, and Show axis of symmetry. 	
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1. A ball is dropped from the top of a building that is 24.5 meters tall. The height h of the ball after t seconds is given by the equation $h = -4.9t^2 + 24.5$.

A. Use a calculator to fill in the h -values in the table below, using $h = -4.9t^2 + 24.5$.

B. Plot the points on the grid to the right. Connect them with a smooth curve.

t	h
-2	
-1	
0	
1	
2	



C. Graph $h = -4.9t^2 + 24.5$ in the Gizmo. (After typing in 24.5 for the value c , click $-$ once to zoom out, and then drag the graph down.)

Use the Gizmo to check your answers, on the graph and in the **TABLE**. Fix any mistakes if needed.

D. What in the graph shows you the ball's initial height? _____

Explain. _____

E. How long does it take for the ball to land? _____ How do you know? _____

F. Explain why negative values of t don't make sense for this scenario. _____

2. Another ball is thrown upward from the same building, 24.5 meters high. The height of this ball after t seconds is given by $h = -4.9t^2 + 19.6t + 24.5$. Graph this function in the Gizmo.

A. What is the maximum height of the ball? _____

How do you know? _____

B. When does the ball hit the ground? _____ Explain. _____

